The glass then gave way, and all the phenomena disappeared except the extreme ends of the cross, and the discharge through the hole, where the glass had been perforated, was alone seen.

The phenomena were seen by Mr. Cottrell, by Mr. Valter (the second assistant), and by myself. A fresh glass plate was at once drilled in hopes of repeating the phenomena in the lecture next day, but owing to sparks springing round we did not succeed in perforating the glass, and therefore saw only the faint return of light described by Dr. Kerr.

Some more glasses have been prepared and their terminals insulated, and I now propose to make another attempt to repeat the new effects before the Royal Society.

February 20, 1879.

THE PRESIDENT in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

I. "On Electrical Insulation in High Vacua." By WILLIAM CROOKES, F.R.S. Received February 6, 1879.

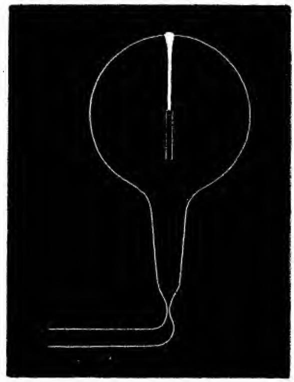
The experiments here described were tried nearly two years ago. They were suggested by some observations I was then making on the passage of an induction current through highly exhausted tubes. The main branch of the research being likely to occupy my attention for some time, I may be unable to return to these less important offshoots. I have ventured, therefore, to embody them in a short note for the "Proceedings of the Royal Society."

A pair of gold leaves were mounted, as for an electroscope, in a bulb blown from English lead glass tubing. The leaves were attached to a glass stem and the lower part of the bulb was drawn out for sealing to a Sprengel pump as shown at fig. 1. A stick of ebonite excited by friction was generally used as the source of electricity, but any other source will do equally well, provided it is not too powerful.

No special attention was paid to the action of electricity on the leaves in air or at moderate vacua, as it agreed with what is already well known. The exhaustion was pushed to a very high degree (about the millionth of an atmosphere), when it was found that the excited

ebonite had a much greater effect on the gold leaves than at a lower exhaustion; for a long time however I was not able to charge the leaves permanently, in consequence of their falling together as soon as the source of electricity was removed.

Fig. 1.



When a hot substance was brought near the bulb facing a gold leaf, so as to warm the glass, molecular repulsion took place, and the leaves retreated from the warm spot, standing out at an angle of about 45°. As the glass cooled the leaves resumed their former vertical position.

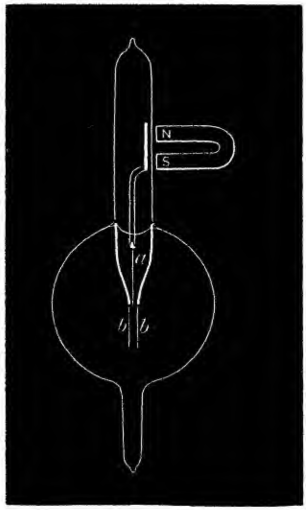
While the leaves were repelled from the hot glass, the excited ebonite had a very powerful action on them, and if it were brought near hastily, the leaves flew off to the side of the glass, destroying the apparatus. By careful management and repeated trials, however, the ebonite could be brought near the warm spot of glass, the leaves suddenly extending at an angle to each other. The appearance was as if a spark had been able to pass across the bridge formed by the line of advancing and retreating molecules connecting the hot glass with the gold leaves. On the ebonite being removed and the glass allowed to cool, it was found that the repulsion of the leaves was permanent. The rubbed ebonite would attract and repel them as it was moved to and fro, but the angle formed by the leaves with one another remained unchanged. A warm body brought near the glass opposite one leaf would repel the pair as a whole; on then warming the opposite side of the glass repulsion on that side took place, the angle of the leaves being somewhat diminished, but on cooling the leaves opened again to their former extent.

When the glass bulb was strongly heated by a spirit flame the leaves suddenly discharged and fell together.

Another bulb (fig. 2) was prepared, containing a plate of mica, *a*, which could be suddenly placed between the gold leaves, *bb*. The

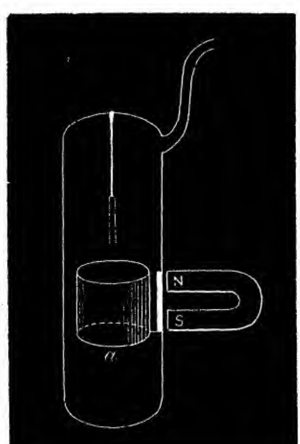
plate of mica was longer and wider than the gold leaves, and was connected with a small piece of iron wire, capable of moving up and

FIG. 2.



down a tube sealed into the top of the bulb. By means of an outside magnet the mica plate could thus be lowered between the gold leaves or raised out of their way, as desired. The tube was exhausted to about the millionth of an atmosphere, the mica plate being held quite above the leaves. One side of the bulb was then heated, and the

FIG. 3.

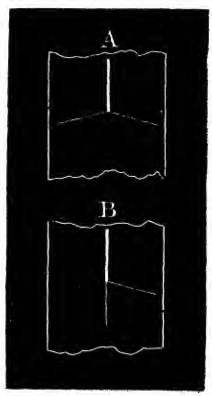


leaves permanently charged by means of the excited ebonite. The mica plate was now carefully lowered. As it came between the gold leaves they diverged further apart, and kept so as long as the mica plate was between them. On removing the plate the leaves reassumed their former divergence. This could be repeated any number of times.

A similar piece of apparatus (fig. 3) was made, only instead of a mica plate coming between the leaves, a mica cylinder, *a*, capable of being raised and lowered outside the divergent leaves, was employed. I was not able to get entirely concordant results with this, owing to the friction of the mica developing electricity on the inner surface of the glass tube; but in all cases, when the cylinder was raised until it covered the electrified leaves, it had the effect of diminishing the angle which they formed with each other.

The following experiments were also tried:—the leaves being separated about 160°, as at fig. 4, A, one side of the tube was slightly

FIG. 4.



heated by a spirit flame. The leaf on that side fell to a vertical position, and remained so when all was cold, the other leaf sticking out as before, as at B. This would seem to show that the divergence of the leaves in this case was not so much due to their mutual repulsion, as to an attraction exerted on each of them by the inner surface of the glass tube. The remaining divergent leaf could be slightly lowered when the glass tube above it was warmed with a bunch of cotton wool dipped in hot water. On cooling the leaf rose again to its original position. When this side of the tube was also heated with a lamp, the leaf was repelled down, but not so readily as the other had been, and when the tube got cold, it rose to nearly its former position. This was repeated several times with uniform results. When the leaf was repelled down, the vertical leaf also

moved away, so as to keep the same angle between them. It is therefore evident that the leaves themselves were also charged.

Fig. 4.

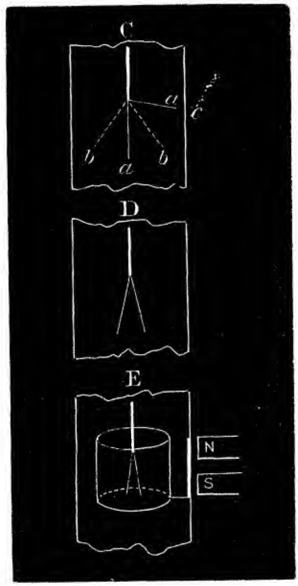


Fig. 4, C, shows the two positions of the leaves, *aa* before applying heat to the side *c* of the tube, and *bb* after heating the glass at *c*.

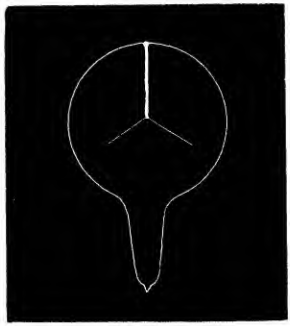
The tube was now heated on both sides, causing the leaves to come nearer together as shown at fig. 4, D. While the glass was warm the cylinder was raised so that it surrounded the leaves: this caused them to get a little closer together, and they kept in this position, shown at E, after the whole apparatus was quite cold.

After remaining thus for some time, the cylinder was lowered, and the leaves widened out and took up the position shown at *bb*, fig. 4, C. They did not return to the position *aa*, showing that their divergence was now owing to their own mutual repulsion, and not to an attraction of one or other to the electrified glass.

In December, 1877, I totally immersed one of these exhausted glass bulbs in a vessel of water; the gold leaves having previously been charged, and standing at an angle of 112° from one another, as at fig. 5. The water was connected electrically with "earth," and the whole was set aside in a cabinet on the 1st of January, 1878.

At the present time, after having remained in this condition for thirteen months, the leaves form exactly the same angle with one another which they did when they were first put in the cabinet.

FIG. 5.



From this experience I think we may consider that at an exhaustion of a millionth of an atmosphere, air is an absolute non-conductor of statical electricity. It is, therefore, legitimate to conclude that the vacuum of interstellar space offers equal obstruction to the discharge of electrified bodies, without necessarily interfering with their mutual repulsion if similarly electrified. It is possible that in these facts an explanation may be found of some obscure celestial phenomena.

II. "On the Reversal of the Lines of Metallic Vapours." No. IV. By G. D. LIVEING, M.A., Professor of Chemistry, and J. DEWAR, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received February 12, 1879.

In the experiments described in the following communication, instead of introducing the substances to be observed in the metallic form into our tubes, we have endeavoured to overcome, to some extent, the difficulty of the presence of impurities by making use of reactions which should generate the metallic vapours within the tubes. For this purpose we have generally employed the great reducing power of carbon and of aluminium at high temperatures.

In a former communication ("Proc. Roy. Soc.," vol. xxvii) we described the reversal of the two blue lines of cæsium and the two violet lines of rubidium by the vapours of those metals, produced by heating their chlorides with sodium in glass tubes. It might be doubtful from these experiments whether the absorption were due to the metals or to the chlorides. To decide this question, we first tried cæsium chloride by itself, heated in a tube such as we used before. No absorption lines could be seen, although a good deal of the chloride had been vaporized and distilled to the cool part of the tube. The experiments were next repeated, both with rubidium and cæsium

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 4.

FIG. 5.